SCIE371-13C

Overview of the potential for Managed Aquifer Recharge as a component for freshwater management in the Poverty Bay flats

Rebekah Haughey

Role: Data collection and collation

Company: Gisborne District Council

Work Supervisor: Clare Houlbrooke (Golder Associates) and Dennis Crone (Gisborne District Council)

University Supervisor: Earl Bardsley

Executive summary

The groundwater resource in the Poverty Bay flats of the Gisborne region is in high demand for irrigation purposes and the demand is continuing to increase. Groundwater levels in the Makauri and Matokitoki Gravel aquifers of the Poverty Bay flats are significantly declining, putting the sustainability of this important resource at risk. As part of Gisborne District Council's freshwater management plan, Managed Aquifer Recharge (MAR) is being proposed as an option for recovering the groundwater levels. MAR technical experts, Golder Associates, provided a three staged assessment process for implementing a MAR project for the Poverty Bay flats. Stage I involves a MAR Feasibility study which requires collection, collation and analysis of data from the Poverty Bay flats. Data includes the hydrology for the catchment, geochemistry of surface/groundwater, groundwater demand and usage and surface/groundwater interactions. This report discusses the data collected and its relevance for the MAR Feasibility study.

The data collected provides Golder with a greater understanding of the MAR feasibility in the Poverty Bay flats. There are two potential MAR methods that could be implemented in the Poverty Bay flats - direct injection through bores and infiltration methods. With the data Golder are required to complete further research and conduct a more in-depth analysis of the potential options and risk management for MAR in the Poverty Bay flats.

Acknowledgements

I would like to thank Clare Houlbrooke and Bob Bower from Golder Associates for their support and direction with the study. I would also like to thank Dennis Cronne, Paul Murphy, Greg Hall and Krystal Williams from Gisborne District Council for their assistance with data collation and analysis.

Table of Contents

List of Figures

List of Tables

1 Introduction

Groundwater levels of the Makauri and Matokitoki Gravel aquifers within the Poverty Bay flats of Gisborne are significantly declining. The Makauri Gravel aquifer is the most extensive gravel deposit beneath the Poverty Bay flats and contains approximately 50% of the allocated groundwater (NIWA, 2009). There is an increasing demand for the abstraction of groundwater that is putting the sustainability of the important groundwater resource at risk. Gisborne District Council (GDC) is currently developing a Freshwater Management Plan in collaboration with the Freshwater Advisory Group (FwAG) which is a representative group of interested freshwater stakeholders. FwaG representatives in conjunction with GDC have established a MAR project team to investigate the potential for Managed Aquifer Recharge (MAR) in the Poverty Bay flats (Golder Associates, 2013a).

Managed Aquifer Recharge (MAR) is a term used to describe a wide range of tools aimed to artificially recharge a targeted aquifer (Golder Associates, 2013b). The proposal firstly involves achieving a MAR feasibility study which is to be completed by MAR technical experts, Golders Associates. For the project Golder require all necessary information and data held by GDC to determine whether the Poverty Bay groundwater system is feasible for the application of MAR (Golder Associates, 2013a). This report discusses the initial data collection for the MAR Feasibility study with an overview of the potential for MAR as a component of the Poverty bay freshwater management plan.

2 Background

Due to suitable climatic conditions the Poverty Bay flats are largely utilized with arable farming, market gardening, viticulture and horticulture. However, the region is also highly susceptible meteorological droughts which often result in limited surface water flows during the summer months. With a limited source of surface water from the Waipaoa River, there is a high demand of groundwater for irrigation purposes (Gordon, 2001). A significant amount of groundwater abstraction for irrigation occurs from the Makauri gravel aquifer (NIWA, 2009). Due to both, identified groundwater level declines in the Makauri gravel aquifer and a growing demand for irrigation in the horticulture industry, there is an unsustainable outlook for the groundwater resource. If not managed adequately the current reliability of water supply in the region will be a constraint on the economic growth (White *et al*, 2012).

Figure 1: Map of the general focus area for MAR in Poverty Bay flats.

2.1 Managed Aquifer Recharge (MAR)

Managed Aquifer Recharge (MAR) is one potential option that could help to improve the sustainability of the groundwater resource in Poverty Bay flats (Golder Associates, 2013a). Replenishment of aquifer systems through the artificial recharge of MAR can be used to replace and/or restore groundwater supplies (both quantity and quality). If successful, MAR can act to balance groundwater storage systems to allow for both sustainable and addition yields (Figure 2). The different tools of MAR can include spreading methods, in-channel modification, boreholes injection, induced bank infiltration and rain harvesting. MAR tools are implemented depending on the conditions of the site/catchment (Golder Associates, 2013b).

For a successful MAR project there are five essential elements to consider:

- A sufficient demand for recovered water
- An adequate source of water for recharge
- An understanding of the seasonality of the available water
- A suitable aquifer for storing and recovering the water
- Sufficient land to harvest and treat water
- Capability to effectively manage a project

  (Dillion, 2009)

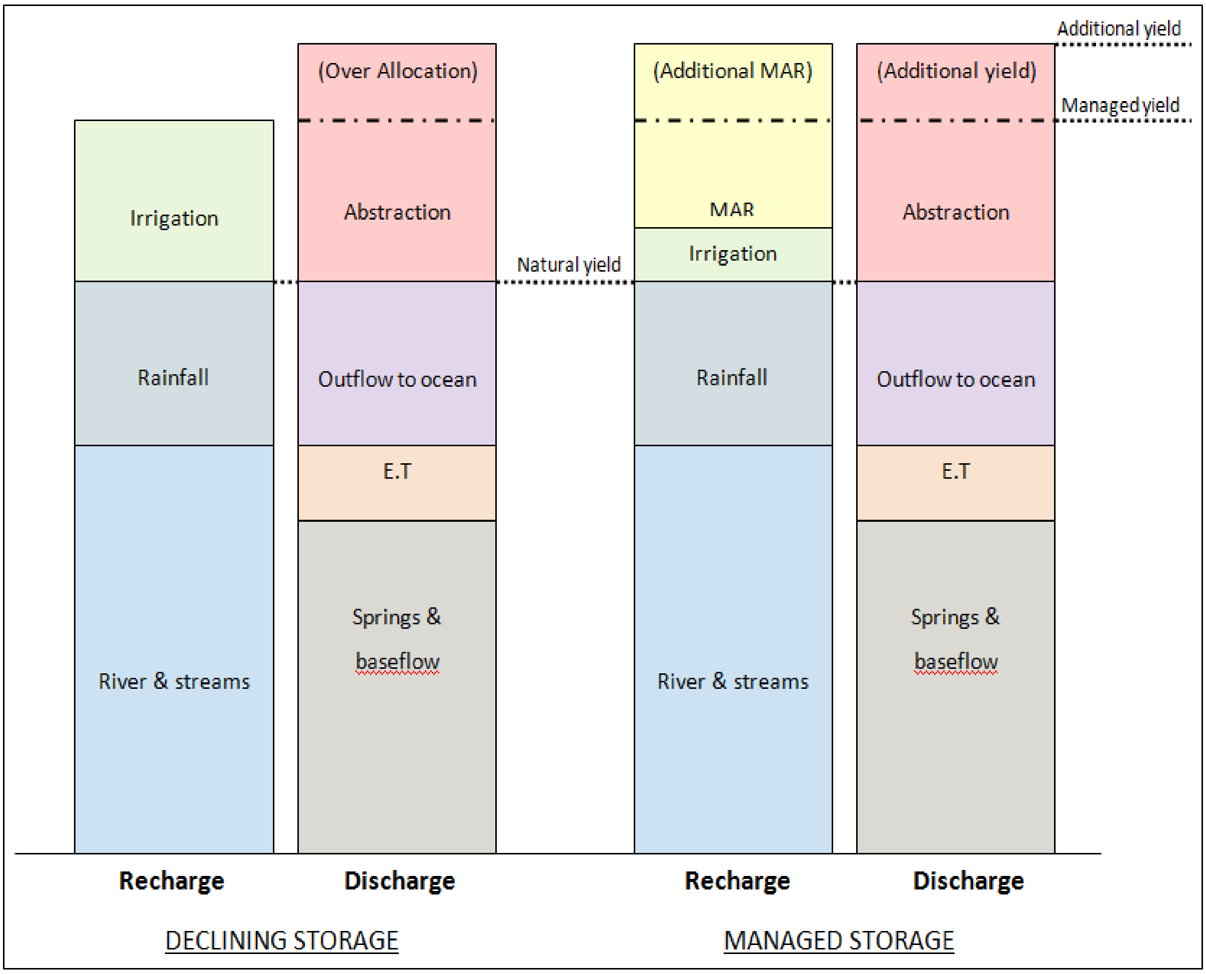

Figure 2: Catchment scale water balance and the use of MAR for sustainable and additional yields (Golder Associates, 2013b).

There are a number of benefits that can be received with the implementation of MAR:

- Groundwater stabilization and restoration
- Increased yields – additional groundwater storage capacity can provide for extra water for further abstraction

- Improved water quality – through recharging high quality water into an aquifer with declining water quality, overall quality is improved through dilution
- Lower carbon footprint by reduced pumping cost (higher water table), also in comparison to carbon footprint produced with construction of equivalent dam storage
- Lower capital cost than equivalent dam storage

  (Golder Associates, 2013b)

2.2 Proposal of MAR for Poverty Bay Flats

There are numerous benefits that could be gained with the application of MAR in the Poverty Bay Flats. However, before developing MAR, it is essential to have a step-wise approach and build a system-specific understanding with the use of pilot testing and catchment-scale modeling (Figure 3) (Golder Associates, 2013a).

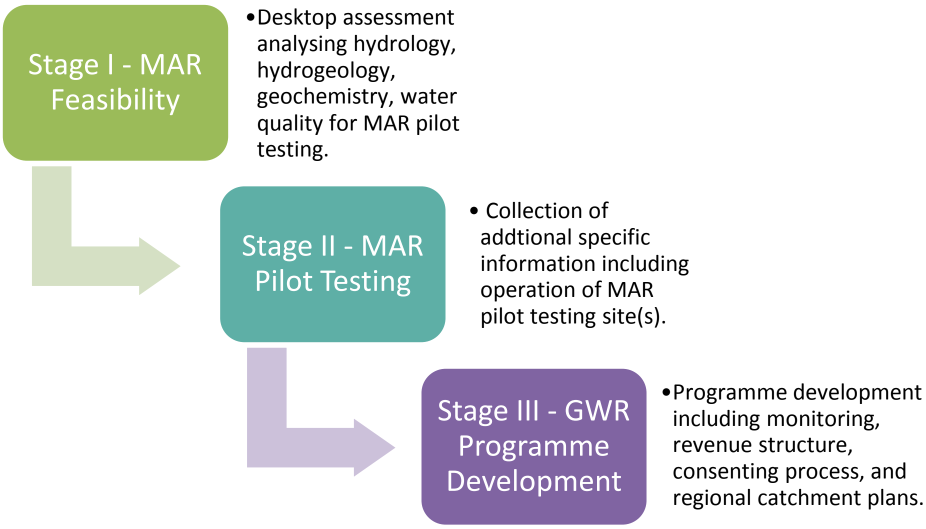

Figure 3: Golder Staged Groundwater Replenishment Assessment Process (Golder Associates, 2013a).

With the proposal of MAR in the Poverty bay flats a collaborative partnership of varied water interests formed. The partnership includes Gisborne District Council (GDC), irrigation interests (Leaderbrand Produce Ltd, Wi Pere Trust, and Horticulture NZ) and local iwi (Te Aitanga a Mahaki). Overseeing the total MAR project is the Gisborne District Groundwater Replenishment Project Governance Team, which includes members from the Freshwater Advisory Group (FwAG) (Table 1). The team is seeking to evaluate MAR with the aim to help resolve the declining groundwater levels.

Table 1: Gisborne District Groundwater Replenishment Project Governance Team.

Name	**Title**	**Organization**	**Interest(s)**
Dennis Crone**	Team Leader	Water Conservation (GDC)	District/ Environmental
Alan Haronga**	Iwi Leader Board Member	Te Aitanga a Mahaki Wi Pere Trust	Cultural/Environmental Water user
Stuart Davis**	Technical Director	Leaderbrand Produce Ltd	Water user
Chris Keenan**	Business Manager	Horticulture NZ	Industry
Bob Bower	Principal Hydrologist	Golder Associates (NZ) Ltd	MAR technical expert
**FwAG members			

2.3 Stage I - MAR Feasibility Study

The MAR Feasibility study is the first step to be completed for the proposal of MAR in the Poverty Bay Flats (Figure 3). This study is to be achieved by technical experts, Golder Associates. Within the MAR feasibility study there are two sub stages. Firstly there is the initial data collection, compilation and analysis of the required data, followed by a second stage involving hydrogeologic modeling (Golder Associates, 2013a). This report mainly focuses on the data collection, compilation and analysis.

In order to gain an understanding of the feasibility for MAR in the Poverty Bay Flats, Golder requires the data held by Gisborne District Council (GDC). Parameters essential for evaluation include:

- Hydrology/hydrogeology for the catchment
- Geochemistry of surface/groundwater
- Current and proposed water uses
- Surface/groundwater interactions
- The quantity and spatial distribution of natural and existing recharge mechanisms

The data needs to be compiled into appropriate formats that enable Golder to complete a desktop assessment of the feasibility. As a result it will allow Golder to look at what methods might be most effective and what locations and timing would be suitable for pilot testing of MAR.

2.4 Hydrological Setting

The Poverty Bay flats are a coastal alluvial plain within the Waipaoa River valley in the East Cape region of the North Island of New Zealand, covering an area of around 18 000 hectares (Taylor, 1993). Surface water across the flats is limited to the Waipaoa River. The river meanders across the flats from the top of the valley and out to the coast, where it discharges into Poverty Bay (Gordon, 2001). It has an extremely high suspended sediment load due to the easily eroded Tertiary mudstones and siltstones within the catchment. Alongside the river are several abandoned river channels, as well as elevated levees, around 3-4 meters above the flats in the lower reaches. There are a few tributary streams on the flats, however most of these are ephemeral and contribute very little to the flow of the Waipaoa River (White *et al*, 2012).

The flats are formed within a broad basin structure that has been in filled with Quaternary terrestrial and marine sediments. Some of these sediments have formed aquifer systems beneath the flats. There are five main aquifers that have been identified including shallow fluvial deposits, Te Hapara sand, Waipaoa gravel aquifer, Makauri gravel and Matokitoki gravel aquifers (White *et al*, 2012).

Associated closely with the coastline is the Te Hapara sand aquifer which lies within about five kilometers of the coast. This aquifer is an unconfined to confined aquifer and consists of beach sands and dune-derived sand. The shallow fluvial aquifer is a semi-confined to confined and is strongly associated with the Waipaoa River (Barber, 1993). This shallow fluvial deposit occurs from Kaitaratahi down to the sand dune and silt deposits inland from the present day coast. It consists mostly of pumice, sands and gravels that are up to 10 meters thick (White *et al,* 2012). Also strongly associated with the Waipaoa River is the Waipaoa gravels aquifer, which was formed through the deposition of channel deposits by the river through the middle of the Poverty Bay flats. This aquifer is about 10-30 meters thick and is semi-confined to confined (Barber, 1993).

The two deep confined aquifers beneath the flats are the Makauri and Matokitoki gravels. The Makauri gravels aquifer is the most extensive aquifer beneath the flats. It lies around 40-80 meters deep and is 3-15 meters thick. The aquifer dips towards the coast making it relatively shallow in the northern parts of the flats and relatively deep in the middle of the flats. The gravel deposit forms a complex ancient braided channel system through silt and clay sediments (Barber, 1993).

The Matokitoki gravel aquifer has artesian pressure and is the deepest aquifer beneath the flats, directly overlying the basement rock (Taylor, 1993). Groundwater within this aquifer is around 4300 years old, showing that there is a very slow flow rate, as a consequence of the absence of a discharge zone. In contrast, the Makauri gravel aquifer has groundwater no older than 100-200 years. All the aquifers beneath the flats, except the Te Hapara Sands aquifer, are 'blind' meaning that they have no direct link with the sea (Gordon, 2001).

The hydrological interactions within the aquifer systems and with surface water are complex and not completely understood. However, some mechanisms of natural recharge have been identified. The Te Hapara Sands aquifer is mostly recharged through infiltration of rainfall as well as some leakage of river derived water from the shallow fluvial deposits. The Waipaoa gravels aquifer has a strong hydraulic connection with the river, resulting in rapid responses in groundwater levels with rises in the river level during high flow events. Recharge of the Waipaoa gravels from the river occurs downstream of Kaitaratahi. Recharge to the Makauri gravels aquifer occurs from three possible sources. Firstly, leakage from the Waipaoa River bed through silts, sands and gravels under pumping stresses. Secondly, recharge from runoff from the hills in the north-eastern side of the flats. Thirdly, there is leakage down from the Waipaoa gravels during summer months. Groundwater within the Matokitoki aquifer is derived mainly from the Waipaoa River. However, its long residence time suggests that recharge occurs at a very slow rate due to lack of a discharge zone. The overall flow of groundwater in the aquifer systems is towards the coast (Barber, 1993).

Groundwater quality varies for the different aquifers. The best water quality is found in the Te Hapara sands, shallow fluvial deposits and parts of the Waipaoa gravel aquifer and the worst water quality is found within the Makauri and Matokitoki gravels (Gordon, 2001). The poor water quality is due to the high iron, hardness and salinity concentrations which increase towards the south-western side of the valley, making a large portion of the groundwater unsuitable for domestic and irrigation purposes. Due to limited interactions with surface water, the deep aquifers have reducing conditions and contain water with long residence times. During the pumping season the quality of water from the Makauri gravels aquifer is further degraded. This can be attributed to the extraction rate exceeding the recharge rate (Barber, 1993).

3 Objectives

The objectives of this report are firstly, to present an overview of the Managed Aquifer Recharge (MAR) Feasibility study and its application for the groundwater management of the Poverty Bay Flats. Secondly, to discuss the initial data collection and compilation relevant to the MAR Feasibility study.

4 Methods

A list of the required data was provided by Golder Associates. Details of bores across the Poverty Bay Flats were obtained through the GDC Bore Database and compiled into Excel spreadsheets. Pump test reports showed pumping drawdown and recovery rates as well as information on the aquifer characteristics including, transmissivity and storage. Raw data, from groundwater water quality testing and static water levels, were abstracted from Hilltop (a hydrological database). Rainfall data was also collected from Hilltop and includes daily rainfall totals and averages at five different sites across the flats. Collection of groundwater demand and usage data involved collating consented volume per day, consented rate of take and actual yearly use from meter-reading sheets which are submitted to GDC by consent holders. Surface water data collection involved raw data abstraction of water quality and low flow gauging from Hilltop.

Additional information required for the MAR feasibility study, such as piping networks and irrigation schemes, was attained through existing GIS files created by GDC. A field tour around the Poverty Bay Flats was also completed to gain greater understanding and information for the MAR Feasibility study. The field tour involved meeting with members of the Gisborne District Groundwater Replenishment Project Governance Team and visiting potential areas for the development of MAR, including old river loops, the Waipaoa augmentation plant, and Wi Pere Trust farm. Participants included members from Golder Associates, Leaderbrand Produce Ltd, Wi Pere Trust, local iwi and GDC.

5 Results

Data collected for the MAR Feasibility study included surface water quality and flow, static water levels, groundwater demand and usage, rainfall and bore details with pump tests, lithology and water quality (Figure 4).

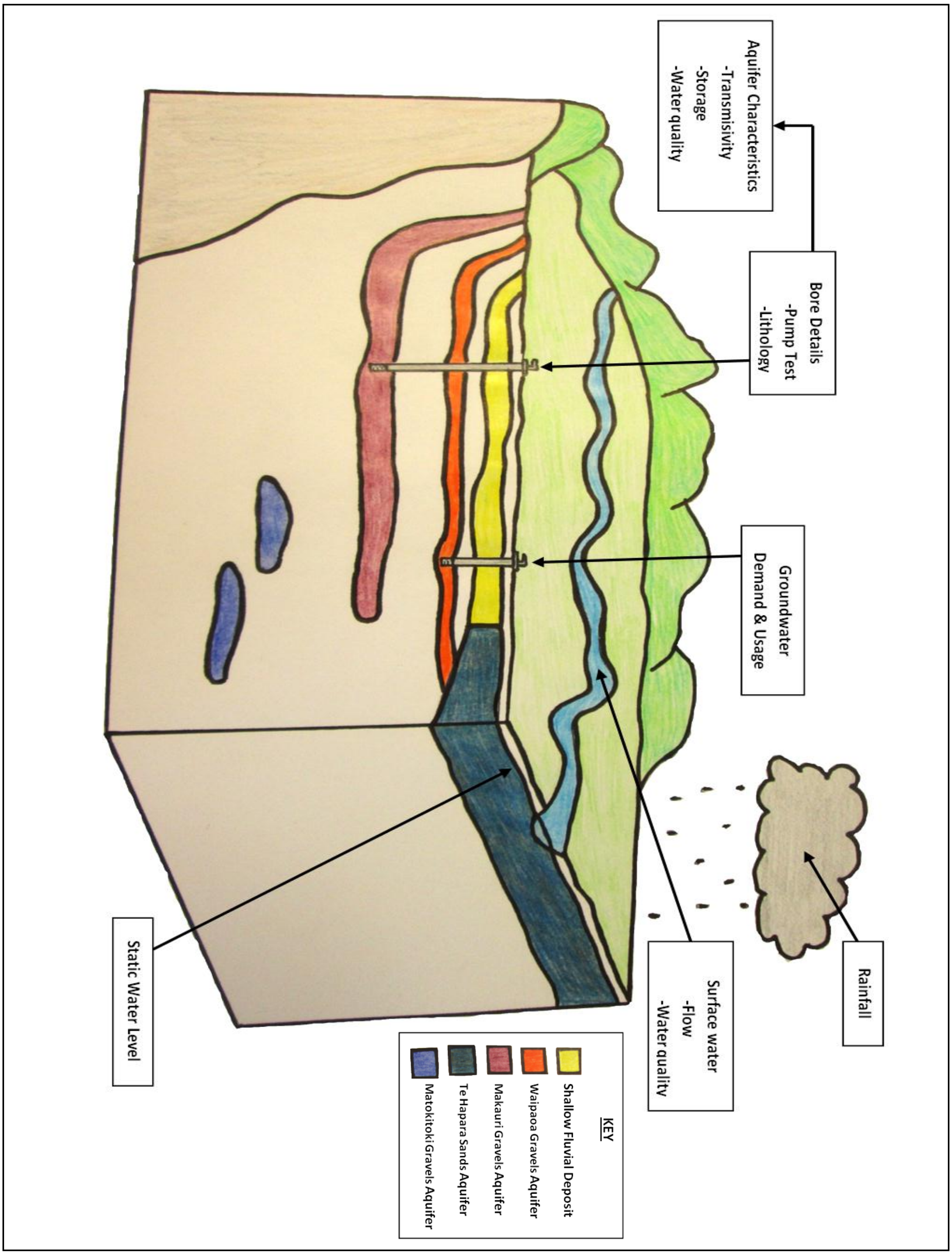

Figure 4: Conceptual model of groundwater and surface water in the Poverty Bay Flats, including data collected for the MAR Feasibility study.

5.1 Surface water

Surface water quality data included samples taken from the Waipaoa River, Whakaahu Stream and Taruheru River. Data from the years 2002 to 2013 were found for pH, salinity, conductivity, biological oxygen demand (BOD), turbidity, facial coliforms, ammonia, sulphate, phosphorous, total hardness, calcium hardness, chloride, sodium, potassium, total suspended solids (TSS), enterococci, temperature and dissolved oxygen (Appendix E). Turbidity, pH, temperature, TSS and BOD within the Waipaoa River were the parameters of most importance for the MAR Feasibility study. High turbidity correlated with high surface water flows in the Waipaoa River during the winter months (Figure 5). Peak turbidity values are under-estimates because the water sampling times are widely separated. pH levels decrease with the high surface water flows (Figure 6).

Figure 5: Plot of flow against turbidity at Kanakanaia Bridge in the Waipaoa River.

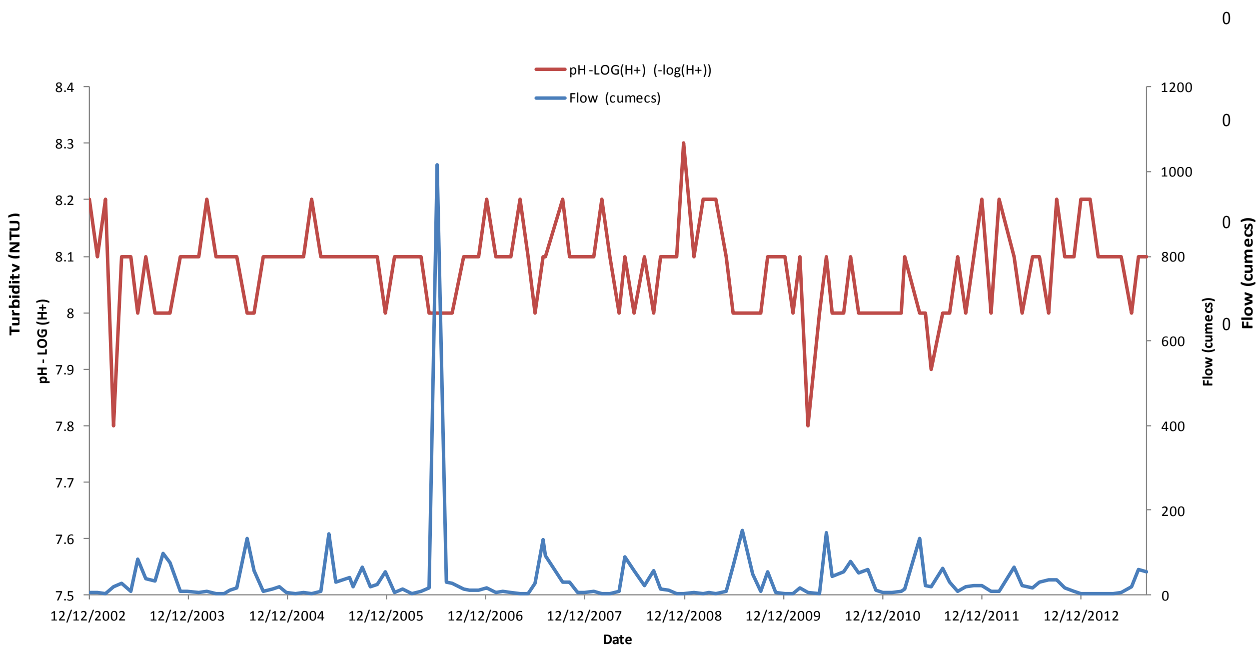

Figure 6: Plot of flow against pH at Kanakanaia Bridge in the Waipaoa River.

Surface water flow data included continuous stage logging from three sites along the Waipaoa River; Kanakanaia Bridge, Kaitaratahi Bridge and Matawhero Bridge. Low flow gauging from numerous sites along the Waipaoa River were also collected (Figure 7 and Figure 8).

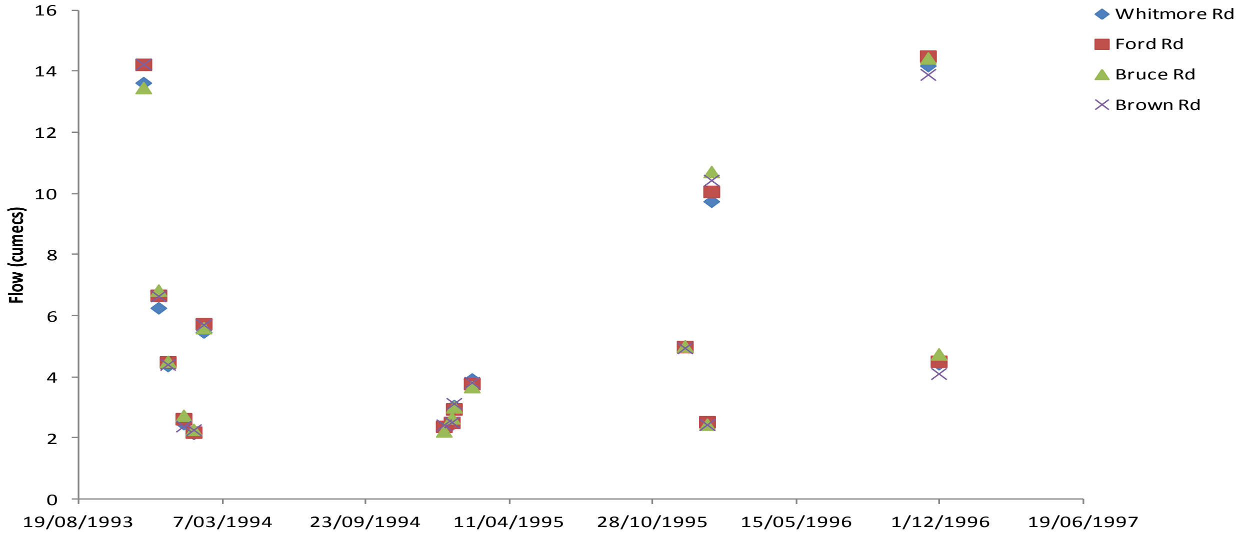

Figure 7: Low flow gauging at five different sites along the Waipaoa River.

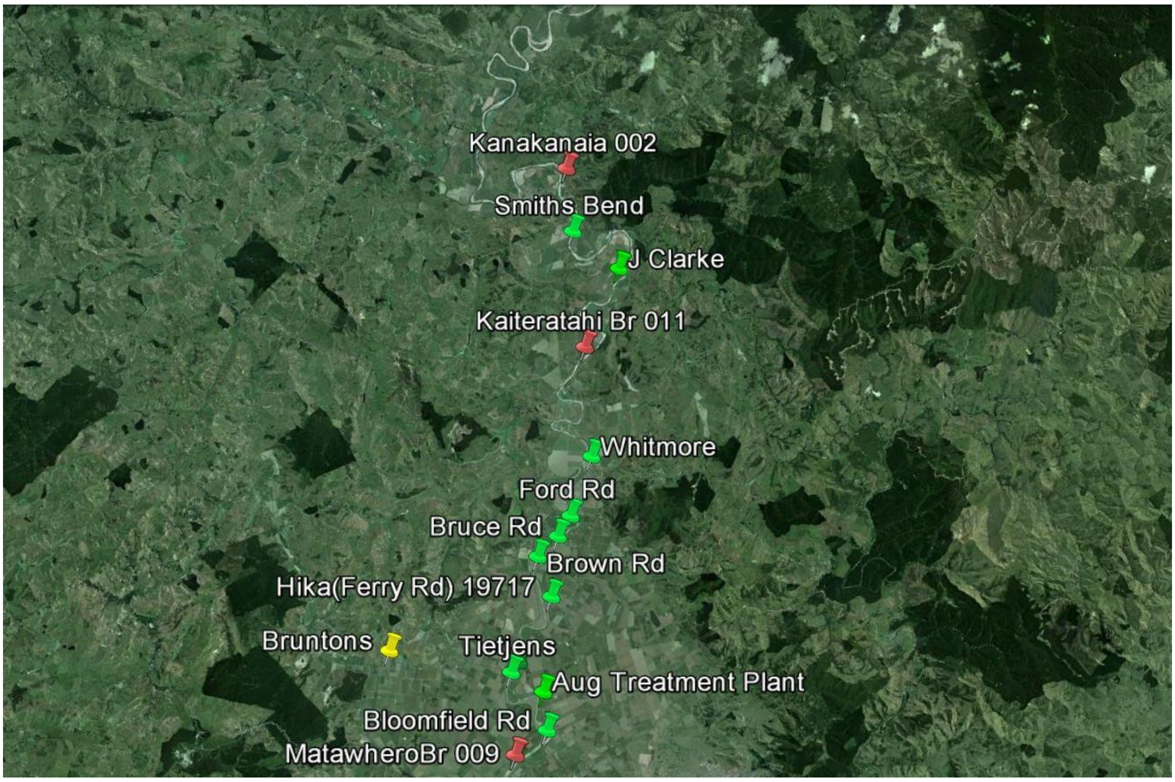

Figure 8: Locations of low gauging sites along the Waipaoa River.

5.2 Static Water Level (SWL)

The static water levels recorded at 43 bores were collected. Bores that tap into the Makauri Gravel aquifer illustrate seasonal variation (Figure 9) with a gradual decline in static water level over the last 30 years (Figure 10). The static water levels within the bores of the Waipaoa Gravel aquifer remain relatively stable with seasonal variation (Figure 11).

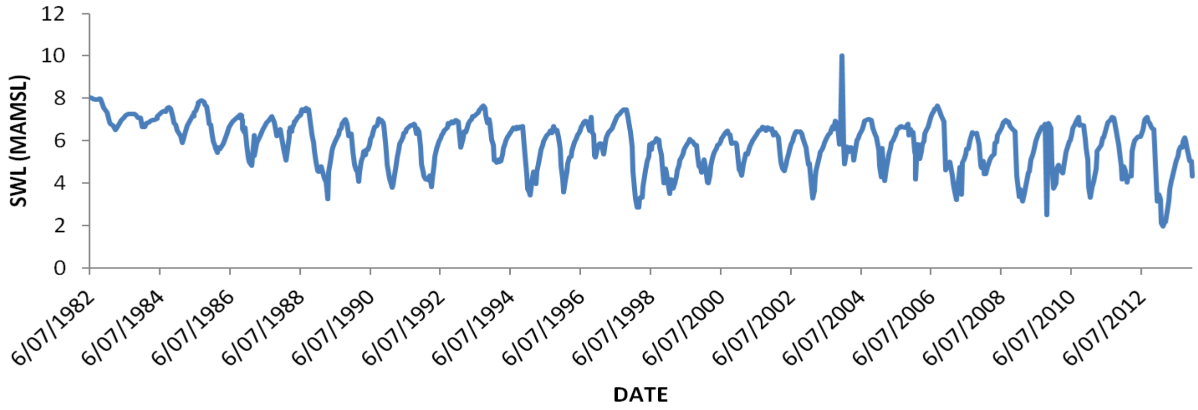

Figure 9: Static water level of Makauri Gravels aquifer in bore GPJ040.

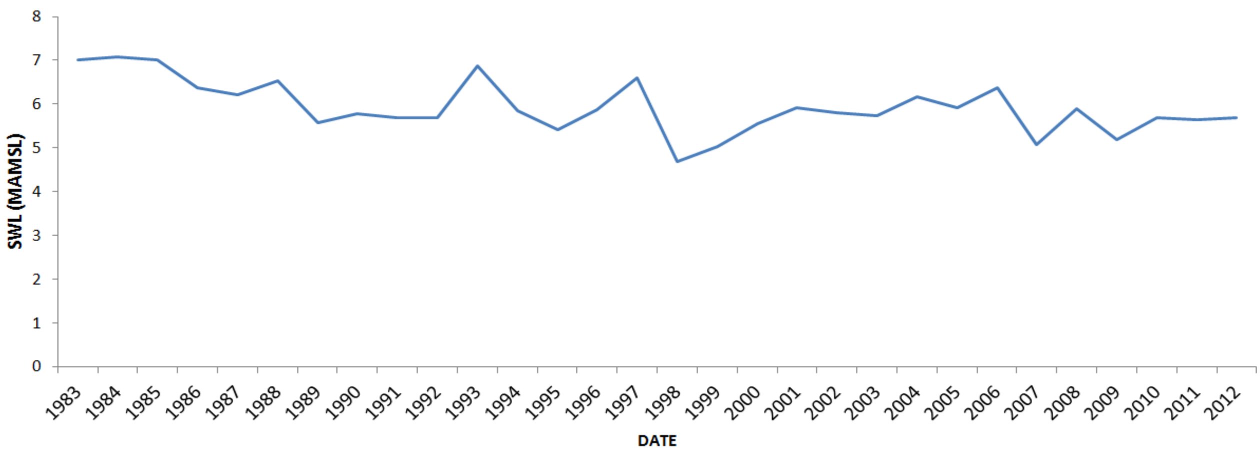

Figure 10: Annual static water level averages of Makauri gravel aquifer in bore GPJ040.

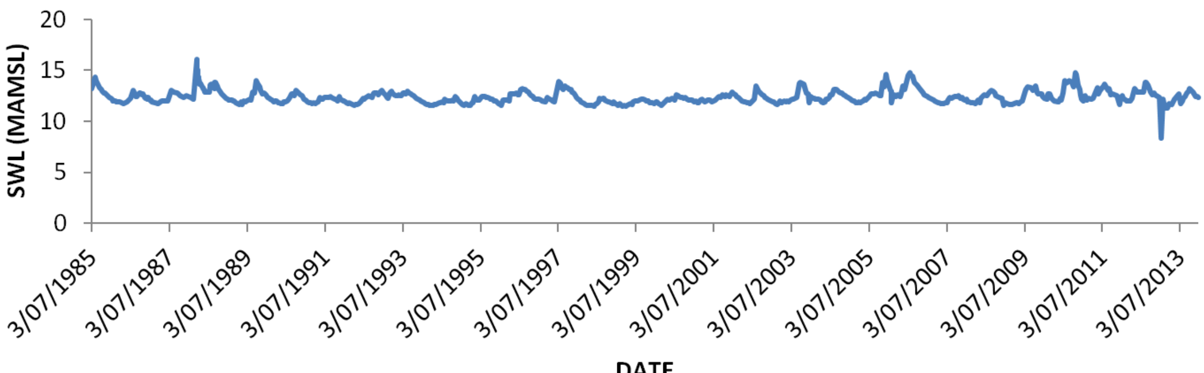

Figure 11: Static water level of Waipaoa Gravels aquifer in bore GPG059.

5.3 Groundwater Demand and Usage

Meter-reading sheets showed that the highest groundwater allocation occurs in the Makauri Gravel aquifer (Appendix D). Allocation of this aquifer accounts for 50% of the total groundwater allocation in the flats. Meter-readings also showed that generally only 25% of total allocation is actually used by consent holders.

5.4 Rainfall

There is seasonal variation in rainfall (Appendix C). In 2013 the highest rainfall occurred during April through to September and lowest rainfall occurred from October through to March. This pattern is generally consistent with the rainfall average from 1961 to 1990 (Figure 12). However, during some years tropical cyclones can cause this pattern to shift. For example, March often can experience high rainfall. Evaporation data for the Poverty Bay flats was unable to be collected for this report.

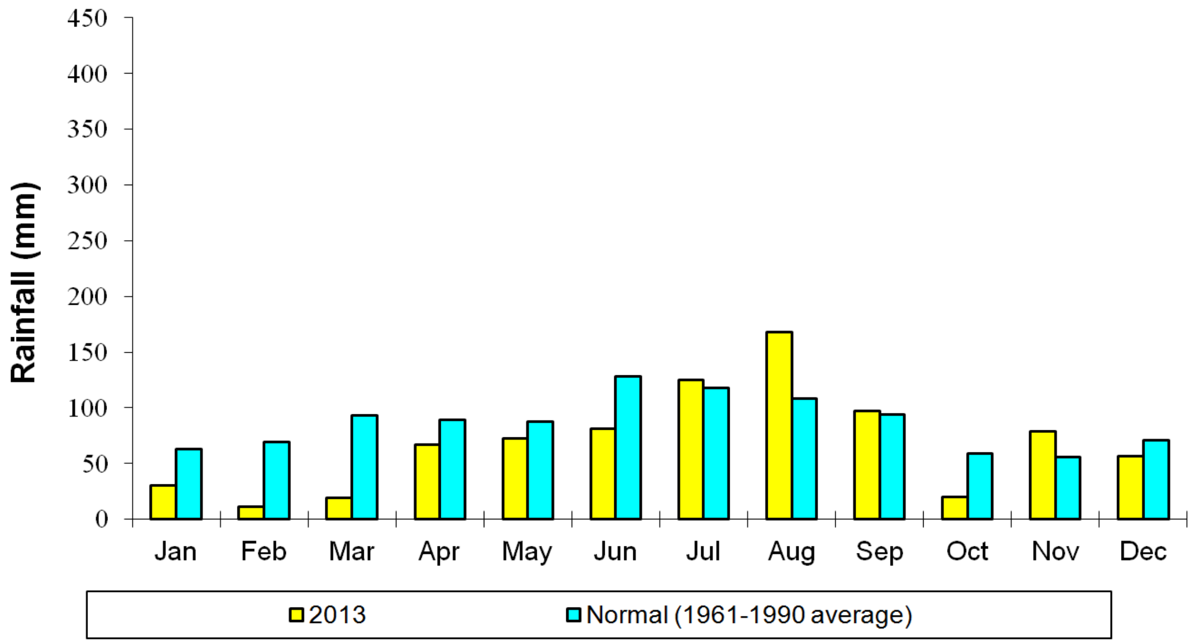

Figure 12: Monthly rainfall totals from 2013 and 2014 compared with monthly rainfall averages from 1961-1990.

5.5 Bore details and aquifer characteristics

The pump tests show that the Makauri Gravel aquifer has the highest transmissivity, with some regions being as high as 2325m^2/day (Appendix B). Groundwater quality samples show that there is high concentration of iron (Appendix A). The concentration levels vary across the flats with the highest iron concentration found in the southern and western boundaries of the Makauri Gravel aquifer.

6 Disscusion

The information collected for the MAR Feasibility study is of important value, as now it allows for Golder to conduct a more in-depth analysis of the potential options and risk management for MAR in the Poverty Bay flats.

6.1 Relevance of data for the MAR Feasibility study

The data collected for surface water flow helps with providing an understanding of groundwater and surface water interactions. For example, the low flow gauging shows that there is very little loss or gain of water in the Waipaoa River between the sites at Whitmore Road and Brown Road (Figure 7). Static water levels can also provide information on any interactions between water sources. Comparing changes in groundwater levels with the changes of flow in the Waipaoa River allows for any correlations to be identified (Appendix A). Understanding the surface water/groundwater interactions will help Golder to identify if there are any regions of natural recharge.

Water quality of the Waipaoa River is important to know as it would be a likely source of water for recharging the groundwater system. Golder need to understand if the water is suitable to use for a recharge source and if so, what time of year water quality and flow conditions would be appropriate. Flows are highest during winter months so this would suggest a suitable time to use water for recharge. However, turbidity and total suspended solids (TSS) increases with flow (Figure 4 and Appendix E). High turbidity and TSS creates poor water quality that would be unsuitable to use for recharge. The Waipaoa Augmentation Water Treatment Plant has infrastructure that could be used to treat the river water before recharge. This option for water treatment needs to be further investigated.

The geochemistry of both surface water and groundwater is essential information for understanding what reactions may take place when water sources are mixed. Groundwater quality across the Poverty Bay flats is generally poor with high iron concentration (Appendix A). In contrast, surface water used for recharge is likely to be higher quality. Golder need to identify what the consequences are of recharging surface water to the groundwater system. This will not only include the chemical reactions but also what effect there may be on any cultural values.

Groundwater demand and usage data is useful for showing where there is the greatest demand for abstraction. Most irrigation takes occur between Kanakanaia Bridge and Matawhero Bridge (Appendix D). It would be beneficial to place a MAR site in proximity to the area with most demand. This data could also provide information on how much more water is required to meet the current and future demand. However, the weakness with the data is that allocated maximum take rate for irrigation appears to be much greater than what is actually taken. This gives an inaccurate measure of the water budget making it difficult to judge how much more water is required.

Golder are able to model and analysis the general hydrogeology of the flats through the lithology logs, static water levels and pump tests that have been collated (Appendix A). Static water levels show the position of the water table and how it changes over time. Static water levels in the Makauri aquifer decline during summer months where pumping demand is greatest. Water levels increase again during the winter months where there is greater surface water flow and less demand however, the overall trend is decreasing showing that abstraction rates are greater than recharge rates (Figure 10). Data from pumping tests are important for the MAR Feasibility study as they provide information on the transmissivity and storage capacity of the aquifers. For MAR Golder need to know if the aquifers are suitable to store the necessary volume of water and how easily the water can be moved through the aquifer for recharge and recovery. High transmissivity within the Makauri aquifer suggests that it could be suitable for the application of MAR (Appendix B). Overall there are many regions of the Poverty Bay flats that lack bores with static water level monitoring and pump tests. This weakness in the data makes it difficult for Golder to complete a sufficient analysis of potential areas for recharge.

6.2 Potential MAR methods for Poverty Bay Flats

With the current data that has been collected, Golder is focusing on two potential options for MAR:

1) Direct injection and recovery of surface water through bore(s).
2) Surface water infiltration methods.

Both methods have benefits and challenges that will arise with application in the Poverty Bay flats. Direct injection through bores has the benefit of targeting the deeper and declining gravel aquifers (Golder Associates, 2013b). The method allows for recharge water to be pumped directly into the necessary aquifer. However, active pumping results in significant costs. Source water could possibly be supplied from river treated water at the Waipaoa Augmentation Water Treatment Plant or from excess water from the Mangapoike Dams; other options may also be feasible.

Infiltration methods include infiltration basins, galleries and existing off-channel features. These methods have a lower cost compared with injection bores however; the weakness is that recharge is less direct. There is significant potential for infiltrated water to be lost to surface water and nearby aquifer systems (Dillon, 2009). Oxbow lakes in the upper regions of the Poverty Bay flats are potential areas for infiltration methods.

7 Conclusions and Recommendations

The data that has been collected will help Golder to complete the Stage I MAR Feasibility study. Further research needs to be done to adequately complete an assessment on the feasibility of Poverty Bay flats for MAR. This would involve looking at areas of data where there is uncertainty. For example, more research needs to be done on water treatment options at the Waipaoa Augmentation Water Treatment Plant, further static water level monitoring in regions where it is lacking, and reviewing the consented water takes with actual abstraction. Potential methods for recharge need to also be further investigated. In conducting further research Golder will be carefully considering the goals/objectives of the Freshwater Advisory Group (FwAG) and project partners, while assessing the regulatory and cultural issues as well as the revenue and costing structure.

If the MAR Feasibility study is successful, the project will move on to Stage II of the Groundwater Replenishment Assessment Process which involves pilot testing of MAR in the Poverty Bay flats. If at any stage the MAR project becomes unfeasible for the groundwater system of Poverty Bay flats then Gisborne District Council will need to consider alternative solutions for the declining groundwater levels in the Makauri and Matokitoki Gravel aquifers.

8 References

Barber, J. L. (1993). Groundwater of the Poverty Bay Flats: A brief synopsis. Gisborne, New Zealand: Gisborne District Council.

Golder Associates. (2013a). *Managing groundwater storage in the Gisborne Poverty Bay Flats groundwater system: Proposal: Feasibility and pilot testing – Managed Aquifer Recharge* (1378110136-001-P-RevB). Christchurch, New Zealand: Golder Associates.

Golder Associates. (2013b). *Selwyn-Te Waihora Land and water planning: Managing groundwater replenishment using Managed Aquifer Recharge (MAR)* (0978110119_009_R_Rev0). Christchurch, New Zealand: Golder Associates.

Gordon, D. (2001). Gisborne. In M.R. Rosen & P.A. White (Eds.), Groundwaters *of New Zealand* (pp.355-366). Wellington, New Zealand: New Zealand Hydrological Society Inc.

Dillon, P. (2009). Water recycling via managed aquifer recharge in Australia. *Boletín Geológicoy Minero*, *120*(2), 121-130.

National Institute of Water & Atmospheric Research Ltd. (2009). *Implications of the proposed national environmental standard on ecological flows and water levels for the Gisborne district* (ELF09203). Christchurch, New Zealand: Norton, N.

Taylor, C. B. (1993). Hydrology of the Poverty Bay flats aquifers, New Zealand: recharge mechanisms, evolution of the isotopic composition of dissolved inorganic carbon, and ground-water ages. *Journal of Hydrology, 158,* 151-185.

White, P.A., Moreau-Fournier, M., Tschritter, C., Murphy, P. (2012). Groundwater in the Poverty Bay Flats*: GNS Science Consultancy Report* (631W1018). Taupo, New Zealand: Institute of Geological and Nuclear Sciences Ltd.

9 Appendices

Appendix A: List of files for bore detail data

File Name	Description
Gisborne MAR project - Boredetailsummary - all_RH_Dec2013	Details of 270 bores across the Poverty Bay Flats. Details include, bore name, elevation, depth, location, aquifer, case diameter, screen diameter, screen length.
Gisborne MAR project - BoreWQ_RH_Dec2013	Groundwater water quality samples from 26 bores. Parameters of water quality include sodium, potassium, aluminium, manganese, pH, conductivity, salinity, total hardness, iron, chloride, sulphate, temperature, calcium, magnesium, ammonia, phosphorous, nitrates and BOD.
Gisborne MAR project - Lithology-GISsheet_RH_Jan2014	Geologic logs recorded on drill dates from 181 bores.
Gisborne MAR project - Monitoringbores_RH_Feb2014	Static water level from GDC monitoring bores, including Caesar rd, Cameron rd, Ferry rd, and Nelson rd bores.
Gisborne MAR project - irondistribution_RH_Feb2014	Average iron concentrations in groundwater samples from 26 bores.

Appendix B: List of files for pump test results

File Name	Description
Gisborne MAR project - pumptest-deepbores_RH_2013	Pump test details (transmisivity/storage) for 25 deep bores
Gisborne MAR project - pumptest-shallowbores_RH_Dec2013	Pump test details (transmisivity/storage) for 21 shallow bores

Appendix C: List of files for rainfall data

File Name	Description
Gisborne MAR project - DailyrainfallPBflats_RH_Dec2013	Daily rainfall totals and averages from 5 sites, including Kanakania Bridge, Courtneys Bridge, Mclaurin

	Bridge, HTL base, Matawhero Bridge.

Appendix D: List of files for groundwater demand and usage data

File Name	Description
Gisborne MAR project - GWusage&demand_RH_Dec2013	Meter-reading spreadsheet summary of consented and actual groundwater usage

Appendix E: List of files for surface water data

File Name	Description
Gisborne MAR project - riverwaterquality_RH-dec2013	Water quality samples from 3 sites along the Waipaoa River. Parameters include pH, salinity, conductivity, biological oxygen demand (BOD), turbidity, facial coliforms, ammonia, sulphate, phosphorous, total hardness, calcium hardness, chloride, sodium, potassium, total suspended solids (TSS), enterococci, temperature and dissolved oxygen.
Gisborne MAR project - riverwaterqualityplots_RH-Jan14	Water quality plots against flow, including turbidity, TSS, pH, temperature and BOD.
Gisborne MAR project - riverflowdata-continous_RH-BB-dec2013	Continous flow loggers from 3 sites along the Waipaoa River – Kanakanaia Bridge, Kaiteratahi Bridge and Matawhero Bridge.
Gisborne MAR project - rivercrosssections_RH_Feb2014	Cross-sections from river bed surveys along the Waipaoa River.
GisborneMAR project - spotgaugings data-RH-BB	Low flow gauging from 5 sites along the Waipaoa River, including Whitmore rd, Ford rd, Bruce rd and Brown rd.